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PATENT ABSTRACTS OF JAPAN

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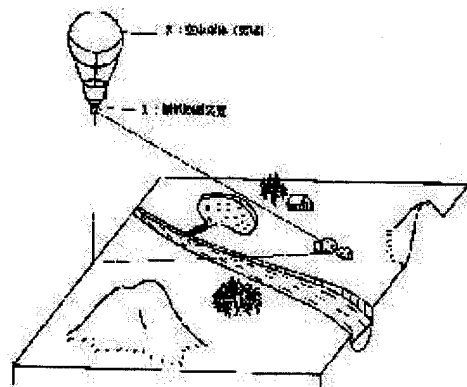
(22)Date of filing : 29.12.1995 (72)Inventor : IIDA TORU

(54) GEODETIC SURVEY METHOD AND DEVICE THEREFOR

(57)Abstract:

PROBLEM TO BE SOLVED: To stabilize a geodetic survey device in air even if a floating body in air is rocked due to the disturbance of, for example, wind regardless of a simple configuration.

SOLUTION: A geodetic method floats a geodetic device 1 where a laser distance meter is mounted to a gimbal which can be freely rotated in horizontal and vertical directions in air by a floating body 2 in air, thus three-dimensionally measuring a point to be measured on the ground. In this case, an



angular velocity around the horizontal axis and/or vertical axis of the gimbal is detected and the above gimbal is driven so that the above angular velocity can be suppressed based on the detection result, thus stabilizing the geodetic survey device 1 in air.

CLAIMS

[Claim(s)]

[Claim 1] The geodetic survey approach characterized by to stabilize said geodetic survey equipment in the air by surfacing the geodetic survey equipment which attached the laser range finder in the gimbal which can rotate freely centering on

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vertical axes and a horizontal axis in the air by the air floating body, being the geodetic survey approach of performing three-dimensions measurement of terrestrial point of measurement-ed, detecting the angular velocity of the circumference of the vertical axes of said gimbal, and/or the circumference of a horizontal axis, and making said gimbal drive based on this detection result so that said angular velocity may be controlled.

[Claim 2] The gimbal support which is at the geodetic survey equipment which performs three-dimensions measurement of the point of measurement-ed in surface of the earth, and was attached in said air floating body while rising to surface in the air by the air floating body, The outer gimbal prepared free [rotation] centering on the vertical axes of this gimbal support, The outer torque motor made to rotate this outer gimbal centering on vertical axes, The outer include-angle detector which detects angle of rotation of said outer gimbal, and the inner gimbal attached in said outer gimbal free [rotation] centering on the horizontal axis, The inner torque motor made to rotate this inner gimbal centering on a horizontal axis, The inner include-angle detector which detects angle of rotation of said inner gimbal, and the laser range finder which is fixed to said inner gimbal and measures the distance by said point of measurement-ed, The angular-velocity detector which is formed in said inner gimbal and detects the angular velocity of the circumference of the revolving shaft of said inner gimbal and said outer gimbal, While making said inner gimbal and/or said outer gimbal drive and controlling the angular velocity of the circumference of the revolving shaft of said inner gimbal and/or said outer gimbal based on the output signal from this angular-velocity detector Geodetic survey equipment characterized by having the signal-processing section which computes the three-dimensions location of said point of measurement-ed based on said outer include-angle detector, said inner include-angle detector, and the output signal from said laser range finder.

[Claim 3] Geodetic survey equipment according to claim 2 carried out to making said inner gimbal and/or said outer gimbal drive compulsorily by transmitting the output signal of said angular-velocity detector, and the same signal to said signal-processing section from an earth station.

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[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention surfaces equipment in the air by air floating bodies, such as a balloon, and relates to the geodetic survey approach and geodetic survey equipment which can stabilize equipment in the air especially about the geodetic survey approach and geodetic survey equipment which perform three-dimensions measurement of point of measurement-ed.

[0002]

[Description of the Prior Art] Three-dimensions measurement of point of measurement-ed was performed by conventional geodetic survey equipment's mainly having the composition of having attached the laser range finder in the gimbal which can rotate freely centering on vertical axes and a horizontal axis, and fixing such geodetic survey equipment to the pole, arranging high up in the sky, and carrying out outgoing radiation of the laser from said laser range finder at point of measurement-ed.

[0003] While measuring the distance L from point of measurement to point of measurement-ed by said laser range finder, angle-of-rotation theta1 degree centering on the vertical axes of said gimbal and angle-of-rotation theta2 degree centering on a horizontal axis were detected, and, specifically, the triaxial coordinate (X, Y, Z) of point of measurement-ed was computed based on these distance L, angle-of-rotation theta1 degree, and theta2 degree.

[0004] However, when geodetic survey equipment was attached in the pole as mentioned above and three-dimensions measurement was performed, the limitation was in the height which geodetic survey equipment installs, and there was a problem that the accuracy of measurement will fall, so that point of measurement-ed became far. then, the former -- air floating bodies, such as a balloon, -- geodetic survey equipment -- carrying -- this air floating body -- empty -- by making it rise to surface highly, installation altitude of geodetic survey equipment was made high, and the accuracy of measurement of a remote place was raised.

[0005] In addition, although three-dimensions measurement of surface of the earth is not performed, in JP,56-39472,A, electromagnetic wave positioning equipment has been arranged high up in the sky by the air floating body, and the geodetic

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survey equipment which performs point to point ranging in the ground or marine was proposed.

[0006] This geodetic survey equipment consisted of a master station located in point of measurement-ed, and a slave station located in a reference point, and each of these master stations and slave stations consisted of two or more electromagnetic wave transponders for measuring the balloon which surfaces over a master station or a slave station, the electromagnetic wave positioning equipment carried in this balloon, and the relative position of said balloon.

[0007] With the geodetic survey equipment which consists of such a configuration, while measuring the relative position of said balloon to point of measurement-ed by said electromagnetic wave transponder, the distance from a reference point to point of measurement-ed was measured by measuring the relative position of said balloon to a reference point, and subsequently measuring the distance between each balloon with electromagnetic wave positioning equipment.

[0008]

[Problem(s) to be Solved by the Invention] however -- the conventional geodetic survey equipment mentioned above -- an air floating body -- geodetic survey equipment -- empty -- since it had become the configuration which measures by making it rise to surface highly, when an air floating body rocked according to disturbance, such as a wind, geodetic survey equipment changed into the condition of having lost stability, and there was a problem that exact three-dimensions measurement of surface of the earth could not be performed.

[0009] In addition, such a problem was unsolvable with the geodetic survey equipment of JP,56-39472,A.

[0010] The above problems will not be produced if it is geodetic survey equipment using Interference SAR (synthetic aperture radar) here. The geodetic survey equipment using Interference SAR installs two sets of antennas in different height. From one antenna, turn microwave to surface of the earth, irradiate it, and coincidence reception of the reflected wave from surface of the earth is carried out with both antennas. In this way, by carrying out image reconstruction processing of the data of the obtained surface of the earth, respectively, and making two kinds of complex image data obtained according to such a process interfere mutually, boom hoisting (altitude) of surface of the earth was measured, and three-dimensions

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measurement was performed.

[0011] However, the geodetic survey equipment using Interference SAR needed the processor for carrying out the image processing of the data obtained by these two sets of two sets of SAR, and SAR, in order to perform three-dimensions measurement, and it had the problem that a system will become large-scale.

[0012] This invention is made in view of the above-mentioned trouble, and though it is an easy configuration, even when an air floating body rocks according to disturbance, such as a wind, it aims at offer of the geodetic survey approach which can stabilize equipment in the air, and geodetic survey equipment.

[0013]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, the geodetic survey approach according to claim 1 The geodetic survey equipment which attached the laser range finder in the gimbal which can rotate freely centering on vertical axes and a horizontal axis is surfaced in the air by the air floating body. It is the geodetic survey approach of performing three-dimensions measurement of terrestrial point of measurement-ed. It has considered as the procedure which stabilizes said geodetic survey equipment in the air by detecting the angular velocity of the circumference of the vertical axes of said gimbal, and/or the circumference of a horizontal axis, and making said gimbal drive based on this detection result, so that said angular velocity may be controlled.

[0014] In order to enforce this geodetic survey approach, moreover, geodetic survey equipment according to claim 2 The gimbal support which is at the geodetic survey equipment which performs three-dimensions measurement of the point of measurement-ed in surface of the earth, and was attached in said air floating body while rising to surface in the air by the air floating body, The outer gimbal prepared free [rotation] centering on the vertical axes of this gimbal support, The outer torque motor made to rotate this outer gimbal centering on vertical axes, The outer include-angle detector which detects angle of rotation of said outer gimbal, and the inner gimbal attached in said outer gimbal free [rotation] centering on the horizontal axis, The inner torque motor made to rotate this inner gimbal centering on a horizontal axis, The inner include-angle detector which detects angle of rotation of said inner gimbal, and the laser range finder which is fixed to said inner gimbal and measures the distance by said point of measurement-ed, The

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angular-velocity detector which is formed in said inner gimbal and detects the angular velocity of the circumference of the revolving shaft of said inner gimbal and said outer gimbal, While making said inner gimbal and/or said outer gimbal drive and controlling the angular velocity of the circumference of the revolving shaft of said inner gimbal and/or said outer gimbal based on the output signal from this angular-velocity detector Based on said outer include-angle detector, said inner include-angle detector, and the output signal from said laser range finder, it has considered as the configuration equipped with the signal-processing section which computes the three-dimensions location of said point of measurement-ed.

[0015] According to such a geodetic survey approach and geodetic survey equipment, by the easy configuration of making the output signal of said angular-velocity detector feed back to drive control of said gimbal (an inner gimbal and outer gimbal), even when an air floating body rocks according to disturbance, such as a wind, geodetic survey equipment can be stabilized in the air.

[0016] Geodetic survey equipment according to claim 3 is considered as the configuration which makes said inner gimbal and/or said outer gimbal drive compulsorily by transmitting the output signal of said angular-velocity detector, and the same signal to said signal-processing section from an earth station. According to such a configuration, angle of rotation centering on the vertical axes and the horizontal axis of said inner gimbal and/or said outer gimbal can be freely adjusted using said signal-processing section.

[0017]

[Embodiment of the Invention] Hereafter, 1 operation gestalt of the geodetic survey approach of this invention and geodetic survey equipment is explained, referring to a drawing. Drawing 1 is the employment conceptual diagram of the geodetic survey equipment concerning 1 operation gestalt of this invention, and drawing 2 is the enlarged drawing of the geodetic survey equipment shown in drawing 1 . Furthermore, drawing 3 is the block diagram of the geodetic survey equipment shown in drawing 2 .

[0018] drawing 1 -- setting -- 1 -- geodetic survey equipment -- it is -- the air floating body (balloon) 2 -- the sky -- it is made to have risen to surface highly This geodetic survey equipment 1 mainly consists of the gimbals and laser distance measuring equipment which can rotate freely centering on vertical axes and a horizontal axis,

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and these control systems, and, specifically, is considered as the configuration as shown in drawing 2 and drawing 3.

[0019] In drawing 2, 10 is a gimbal support. Geodetic survey equipment 1 is fixed to the air floating body 2 through this gimbal support 10. Moreover, as shown in drawing 3, under the gimbal support 10, the outer gimbal 20 of the inverted-U character mold which can rotate freely centering on vertical axes 21 is provided. Moreover, the outer torque motor 11 made to rotate the outer gimbal 20 centering on vertical axes 21 is built in the interior of the gimbal support 10. Furthermore, the outer include-angle detector 12 which detects angle-of-rotation θ_1 degree of the outer gimbal 20 through vertical axes 21 is formed in the gimbal support 10.

[0020] The inner gimbal 30 which can rotate freely centering on a horizontal axis 31 is formed in the outer gimbal 20. Moreover, the inner torque motor 32 made to rotate the inner gimbal 30 centering on a horizontal axis 31 is attached in the end of a horizontal axis 31, and the inner include-angle detector 33 which detects angle-of-rotation θ_2 degree of the inner gimbal 30 is formed in the other end of a horizontal axis 31.

[0021] Furthermore, the laser range finder 40 which measures the distance by point of measurement-ed, and the angular-velocity detector 50 which detects each revolving shaft 31 of the inner gimbal 30 and the outer gimbal 20 and the angular velocity of the circumference of 21 are formed in the inner gimbal 30.

[0022] The laser range finder 40 has measured the distance L from point of measurement to point of measurement-ed by having the lens 41 for transmission, and the lens 42 for reception, carrying out outgoing radiation of the pulsed light from the lens 41 for transmission at point of measurement-ed, and receiving the reflective pulse from point of measurement-ed with the lens 42 for reception, as shown in drawing 2. Moreover, the rate sensor used for the satellite or the missile is used for the angular-velocity detector 50.

[0023] In drawing 3, 60 is the signal-processing section, based on the output signal from the angular-velocity detector 50, it makes the inner gimbal 30 and/or the outer gimbal 20 drive, controls each revolving shaft 31 of the inner gimbal 30 and/or the outer gimbal 20, and the angular velocity of the circumference of 21, and is stabilizing the geodetic survey equipment 1 in the air.

[0024] Moreover, the signal-processing section 60 computes the three-dimensions

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location of said point of measurement-ed based on angle-of-rotation θ_1 degree, θ_2 degree, and distance L which the outer include-angle detector 12, the inner include-angle detector 33, and a laser range finder 30 output, respectively.

[0025] In addition, although considered as the configuration which performs both stabilization of geodetic survey equipment 1, and measurement of a three-dimensions location by the signal-processing section 60 with this operation gestalt, it is good also as a configuration which forms the two signal-processing sections 60 and performs these separately.

[0026] Next, the geodetic survey approach of the geodetic survey equipment 1 which consists of the above-mentioned configuration is explained, referring to drawing 1, drawing 4, and drawing 5. Drawing 4 is the explanatory view showing the procedure of three-dimensions measurement of the above-mentioned geodetic survey equipment. Moreover, drawing 5 is the explanatory view showing the procedure of stabilizing the above-mentioned geodetic survey equipment in the air.

[0027] First, the procedure of three-dimensions measurement of the point of measurement-ed in geodetic survey equipment 1 is explained. it is shown in drawing 1 -- as -- the air floating body 2 -- geodetic survey equipment 1 -- the sky -- it arranges highly, the outer gimbal 20 and the inner gimbal 30 are rotated centering on vertical axes 21 and a horizontal axis 31, and the criterion of a laser range finder 40 is doubled with point of measurement-ed.

[0028] Here, if the installation location (point of measurement) of geodetic survey equipment 1 is set to P and point of measurement-ed is set to Q as shown in drawing 4, the triaxial coordinate (X, Y, Z) of the point of measurement Q-ed will be searched for as follows. 1. Input into the signal-processing section 60 the altitude H of the point of measurement P which was determined beforehand or was measured with the altimeter. 2. Input angle-of-rotation θ_1 degree of the outer gimbal 20, and angle-of-rotation θ_2 degree of the inner gimbal 30 into the signal-processing section 60 from the outer include-angle detector 12 and the inner include-angle detector 33. 3. Moreover, input the distance L from the point of measurement P to the point of measurement Q-ed into the signal-processing section 60 from a laser range finder 30. 4. It is based on these altitude H, angle-of-rotation θ_1 degree and θ_2 degree, and distance L, and the signal-processing section 60 is a bottom type (1). - (3) An operation [like] is

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performed and the triaxial coordinate (X, Y, Z) of the point of measurement Q-ed is computed.

[0029]

$X = L \cdot \sin \theta_2$ degree and $\sin \theta_1$ degree -- (1) $Y = L \cdot \sin \theta_2$ degree and $\cos \theta_1$ degree -- (2) $Z = H - L \cdot \cos \theta_2$ degree -- (3) [0030] Next, the procedure of stabilizing geodetic survey equipment in the air is explained. For example, if the air floating body 2 rotates by α "/s clockwise centering on vertical axes A according to disturbance, such as a wind, as shown in drawing 5, the outer gimbal 20 attached in the air floating body 2 will also rotate by α "/s clockwise centering on vertical axes A.

[0031] Then, the angular-velocity detector 50 detects angular-velocity α "/s of the clockwise rotation of the outer gimbal 20, and outputs this to the signal-processing section 60. And the signal-processing section 60 which inputted this signal changes angular-velocity α "/s into $-\alpha$ "/s, makes the outer torque motor 11 drive based on this, and does α "/s rotation of the outer gimbal 20 counterclockwise.

[0032] Thereby, movement of the clockwise rotation of the air floating body 2 and movement of the counterclockwise rotation of the outer gimbal 20 negate each other, and can stabilize geodetic survey equipment 1 in the air. That is, the criterion of a laser range finder 30 can always be doubled with point of measurement-ed also in the condition that the air floating body 2 is rotating.

[0033] Moreover, also when the air floating body 2 rocks perpendicularly, geodetic survey equipment 1 can be stabilized by rotating the inner gimbal 30 centering on a horizontal axis 31 in the same procedure.

[0034] In addition, the inner gimbal 30 and/or the outer gimbal 20 can be made to drive compulsorily by the configuration which can transmit the output signal of the angular-velocity detector 50, and the same signal to the signal-processing section 60 from the earth station which is not illustrated, then the command from said earth station.

[0035] According to such a configuration, the criterion of a laser range finder 30 can be freely changed by the command from said earth station.

[0036] According to the geodetic survey approach of such this operation gestalt, and geodetic survey equipment, by the easy configuration of making the output

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signal of the angular-velocity detector 50 feed back to drive control of the inner gimbal 30 and the outer gimbal 20, even when the air floating body 2 rocks according to disturbance, such as a wind, geodetic survey equipment 1 can be stabilized in the air.

[0037]

[Effect of the Invention] As mentioned above, though it is an easy configuration, even when an air floating body rocks according to disturbance, such as a wind, according to the geodetic survey approach of this invention, and geodetic survey equipment, equipment can be stabilized in the air.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the employment conceptual diagram of the geodetic survey equipment concerning 1 operation gestalt of this invention.

[Drawing 2] It is the enlarged drawing of the geodetic survey equipment shown in drawing 1 .

[Drawing 3] It is the block diagram of the geodetic survey equipment shown in drawing 2 .

[Drawing 4] It is the explanatory view showing the procedure of the three-dimensions measurement in the geodetic survey approach of this invention.

[Drawing 5] It is the explanatory view showing the procedure of stabilizing the geodetic survey equipment in the geodetic survey approach of this invention in the air.

[Description of Notations]

1 Geodetic Survey Equipment

2 Air Floating Body (Balloon)

10 Gimbal Support

11 Outer Torque Motor

12 Outer Include-Angle Detector

20 Outer Gimbal

21 Vertical Axes

30 Inner Gimbal

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31 Horizontal Axis

32 Inner Torque Motor

33 Inner Include-Angle Detector

40 Laser Range Finder

50 Angular-Velocity Detector

60 Signal-Processing Section

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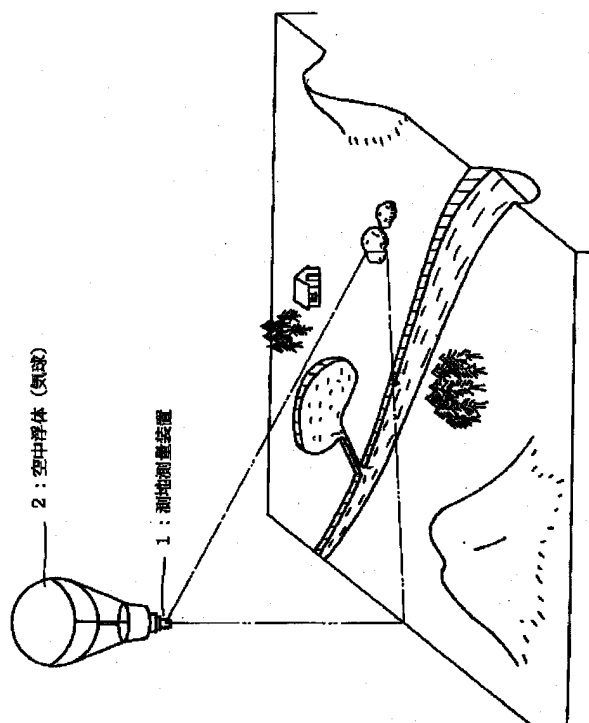
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(54) 【発明の名称】 測地測量方法及び測地測量装置

(57) 【要約】

【課題】 簡単な構成でありながら、風等の外乱により空中浮体が揺動した場合でも、測地測量装置を空中において安定させることができるようにする。

【解決手段】 水平方向及び垂直方向に回動自在なジンバルにレーザ距離計を取り付けた測地測量装置1を空中浮体2によって空中に浮上させ、地上における被測定点の三次元計測を行なう測地測量方法であって、前記ジンバルの水平軸回り及び／又は垂直軸回りの角速度を検出し、この検出結果にもとづいて、前記角速度を抑制するように前記ジンバルを駆動させることにより、測地測量装置1を空中で安定させる手順としてある。



【特許請求の範囲】

【請求項1】 垂直軸及び水平軸を中心に回動自在なジンバルにレーザ距離計を取り付けた測地測量装置を空中浮体によって空中に浮上させ、地上における被測定点の三次元計測を行なう測地測量方法であって、前記ジンバルの垂直軸回り及び／又は水平軸回りの角速度を検出し、この検出結果にもとづいて、前記角速度を抑制するように前記ジンバルを駆動させることにより、前記測地測量装置を空中で安定させることを特徴とする測地測量方法。

【請求項2】 空中浮体によって空中に浮上しながら、地表における被測定点の三次元計測を行なう測地測量装置にあって、前記空中浮体に取り付けたジンバルサポートと、このジンバルサポートの垂直軸を中心に回動自在に設けたアウトジンバルと、このアウトジンバルを垂直軸を中心に回動させるアウトトルクモータと、前記アウトジンバルの回転角度を検出するアウト角度検出器と、前記アウトジンバルに水平軸を中心に回動自在に取り付けたインナジンバルと、このインナジンバルを水平軸を中心に回動させるインナトルクモータと、前記インナジンバルの回転角度を検出するインナ角度検出器と、前記インナジンバルに固定され、前記被測定点までの距離を計測するレーザ距離計と、前記インナジンバルに設けられ、前記インナジンバル及び前記アウトジンバルの回転軸回りの角速度を検出する角速度検出器と、この角速度検出器からの出力信号にもとづいて、前記インナジンバル及び／又は前記アウトジンバルを駆動させ、前記インナジンバル及び／又は前記アウトジンバルの回転軸回りの角速度を抑制するとともに、前記アウト角度検出器、前記インナ角度検出器及び前記レーザ距離計からの出力信号にもとづいて、前記被測定点の三次元位置を算出する信号処理部とを備えたことを特徴とする測地測量装置。

【請求項3】 地上局から前記信号処理部に、前記角速度検出器の出力信号と同様の信号を送信することにより、前記インナジンバル及び／又は前記アウトジンバルを強制的に駆動させることとした請求項2記載の測地測量装置。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、気球等の空中浮体により装置を空中に浮上させ、被測定点の三次元測定を行なう測地測量方法及び測地測量装置に関し、特に、装

及び測地測量装置に関する。

【0002】

【従来の技術】従来の測地測量装置は、主として、垂直軸及び水平軸を中心に回動自在なジンバルにレーザ距離計を取り付けた構成となっており、このような測地測量装置をポールに固定して上空に配置し、前記レーザ距離計から被測定点にレーザを出射することにより、被測定点の三次元計測を行なっていた。

【0003】具体的には、前記レーザ距離計によって測定点から被測定点までの距離 L を測定するとともに、前記ジンバルの垂直軸を中心とする回転角度 $\theta 1^\circ$ 、及び、水平軸を中心とする回転角度 $\theta 2^\circ$ を検出し、これら距離 L 、回転角度 $\theta 1^\circ$ 及び $\theta 2^\circ$ にもとづいて被測定点の三軸座標(X , Y , Z)を算出していた。

【0004】ところが、上記のように測地測量装置をポールに取り付けて三次元計測を行なった場合、測地測量装置の設置する高さに限界があり、被測定点が遠くなるほど測定精度が低下してしまうという問題があった。そこで、従来は、気球等の空中浮体に測地測量装置を搭載し、この空中浮体を空高く浮上させることによって測地測量装置の設置高度を高くし、遠隔地の測定精度を向上させていた。

【0005】なお、地表の三次元計測を行なうものではないが、特開昭56-39472号では、空中浮体によって電磁波測位装置を上空に配置し、地上又は海上における二点間の測距を行なう測地測量装置が提案されていた。

【0006】この測地測量装置は、被測定点に位置する主局と、基準点に位置する従局とからなり、これら主局と従局はいずれも、主局又は従局の上空に浮上する気球と、この気球に搭載された電磁波測位装置と、前記気球の相対位置を測定するための複数の電磁波トランスポンダとで構成してあった。

【0007】このような構成からなる測地測量装置では、前記電磁波トランスポンダによって、被測定点に対する前記気球の相対位置を測定するとともに、基準点に対する前記気球の相対位置を測定し、次いで、電磁波測位装置によって各気球間の距離を測定することにより、基準点から被測定点までの距離を測定していた。

【0008】

【発明が解決しようとする課題】ところが、上述した従来の測地測量装置では、空中浮体によって測地測量装置を空高く浮上させて測定を行なう構成となっていたので、空中浮体が風等の外乱によって揺動した場合、測地測量装置が安定性を失った状態となり、地表の正確な三次元計測を行なうことができないという問題があった。

【0009】なお、特開昭56-39472号の測地測量装置でも、このような問題を解決することができなかつた。

用いた測地測量装置ならば、上記のような問題は生じない。干渉SARを用いた測地測量装置は、二台のアンテナを異なる高さに設置して、一方のアンテナからマイクロ波を地表に向けて照射し、地表からの反射波を双方のアンテナで同時受信し、こうして得た地表のデータをそれぞれ画像再生処理し、このようなプロセスによって得た二種類の複素画像データを互いに干渉させることにより、地表の起伏（標高）を測定し三次元計測を行なっていた。

【0011】しかし、干渉SARを用いた測地測量装置は、三次元計測を行なうために二台のSARと、これら二台のSARによって得られたデータを画像処理するための処理装置とを必要とし、システムが大がかりになってしまうという問題があった。

【0012】本発明は、上記問題点にかんがみてなされたものであり、簡単な構成でありながら、風等の外乱により空中浮体が揺動した場合でも、装置を空中において安定させることができる測地測量方法及び測地測量装置の提供を目的とする。

【0013】

【課題を解決するための手段】上記目的を達成するために、請求項1記載の測地測量方法は、垂直軸及び水平軸を中心に回動自在なジンバルにレーザ距離計を取り付けた測地測量装置を空中浮体によって空中に浮上させ、地上における被測定点の三次元計測を行なう測地測量方法であって、前記ジンバルの垂直軸回り及び／又は水平軸回りの角速度を検出し、この検出結果にもとづいて、前記角速度を抑制するように前記ジンバルを駆動させることにより、前記測地測量装置を空中で安定させる手順としてある。

【0014】また、この測地測量方法を実施するため、請求項2記載の測地測量装置は、空中浮体によって空中に浮上しながら、地表における被測定点の三次元計測を行なう測地測量装置にあって、前記空中浮体に取り付けたジンバルサポートと、このジンバルサポートの垂直軸を中心に回動自在に設けたアウトジンバルと、このアウトジンバルを垂直軸を中心に回動させるアウトトルクモータと、前記アウトジンバルの回転角度を検出するアウト角度検出器と、前記アウトジンバルに水平軸を中心に回動自在に取り付けたインジンバルと、このインジンバルを水平軸を中心に回動させるイントルクモータと、前記インジンバルの回転角度を検出するイン角度検出器と、前記インジンバルに固定され、前記被測定点までの距離を計測するレーザ距離計と、前記インジンバルに設けられ、前記インジンバル及び前記アウトジンバルの回転軸回りの角速度を検出する角速度検出器と、この角速度検出器からの出力信号にもとづいて、前記インジンバル及び／又は前記アウトジンバルを駆動させ、前記インジンバル及び／又は前記アウト

記アウト角度検出器、前記イン角度検出器及び前記レーザ距離計からの出力信号にもとづいて、前記被測定点の三次元位置を算出する信号処理部とを備えた構成としてある。

【0015】このような測地測量方法及び測地測量装置によれば、前記角速度検出器の出力信号を前記ジンバル（インジンバル及びアウトジンバル）の駆動制御にフィードバックさせるといった簡単な構成によって、風等の外乱により空中浮体が揺動した場合でも、測地測量装置を空中において安定させることができる。

【0016】請求項3記載の測地測量装置は、地上局から前記信号処理部に、前記角速度検出器の出力信号と同様の信号を送信することにより、前記インジンバル及び／又は前記アウトジンバルを強制的に駆動させる構成としてある。このような構成によれば、前記信号処理部を利用して前記インジンバル及び／又は前記アウトジンバルの、垂直軸及び水平軸を中心とする回転角度を自由に調整することができる。

【0017】

【発明の実施の形態】以下、本発明の測地測量方法及び測地測量装置の一実施形態について、図面を参照しつつ説明する。図1は本発明の一実施形態に係る測地測量装置の運用概念図であり、また、図2は図1に示す測地測量装置の拡大図である。さらに、図3は図2に示す測地測量装置のブロック図である。

【0018】図1において、1は測地測量装置であり、空中浮体（気球）2によって上空高く浮上させてある。この測地測量装置1は、主として、垂直軸及び水平軸を中心に回動自在なジンバル、レーザ測距装置及びこれらの制御系からなっており、具体的には、図2及び図3に示すような構成としてある。

【0019】図2において、10はジンバルサポートである。測地測量装置1はこのジンバルサポート10を介して空中浮体2に固定してある。また、図3に示すように、ジンバルサポート10の下方には、垂直軸21を中心に回動自在な逆U字型のアウトジンバル20が設けてある。また、ジンバルサポート10の内部には、垂直軸21を中心にアウトジンバル20を回動させるアウトトルクモータ11が内蔵してある。さらに、ジンバルサポート10には、垂直軸21を介してアウトジンバル20の回転角度 $\theta 1^\circ$ を検出するアウト角度検出器12が設けてある。

【0020】アウトジンバル20には、水平軸31を中心に回動自在なインジンバル30が設けてある。また、水平軸31の一端には、水平軸31を中心にインジンバル30を回動させるイントルクモータ32が取り付けられており、水平軸31の他端には、インジンバル30の回転角度 $\theta 2^\circ$ を検出するイン角度検出器33が設けてある。

点までの距離を計測するレーザ距離計40と、インナジンバル30及びアウトジンバル20の各回転軸31, 21回りの角速度を検出する角速度検出器50とが設けられている。

【0022】レーザ距離計40は、例えば、図2に示すように、送信用レンズ41と受信用レンズ42を備え、送信用レンズ41から被測定点にパルス光を出射し、被測定点からの反射パルスを受信用レンズ42で受光することにより、測定点から被測定点までの距離Lを測定している。また、角速度検出器50には、例えば、人工衛星やミサイルに用いられているレートセンサを用いている。

【0023】図3において、60は信号処理部であり、角速度検出器50からの出力信号にもとづいて、インナジンバル30及び／又はアウトジンバル20を駆動させ、インナジンバル30及び／又はアウトジンバル20の各回転軸31, 21回りの角速度を抑制し、空中における測地測量装置1を安定させている。

【0024】また、信号処理部60は、アウト角度検出器12、インナ角度検出器33及びレーザ距離計30がそれぞれ出力する回転角度 $\theta 1^\circ$ 、 $\theta 2^\circ$ 及び距離Lにもとづいて、前記被測定点の三次元位置を算出する。

【0025】なお、本実施形態では、信号処理部60により、測地測量装置1の安定化と三次元位置の測定の両方を行なう構成としたが、信号処理部60を二つ設けてこれらを別個に行なう構成としてもよい。

【0026】次に、上記構成からなる測地測量装置1の測地測量方法について、図1、図4及び図5を参照しつつ説明する。図4は上記測地測量装置の三次元計測の手順を示す説明図である。また、図5は上記測地測量装置を空中において安定化させる手順を示す説明図である。

【0027】まず、測地測量装置1における被測定点の三次元計測の手順について説明する。図1に示すように、空中浮体2により測地測量装置1を上空高く配置し、アウトジンバル20及びインナジンバル30を、垂直軸21及び水平軸31を中心に回動させてレーザ距離計40の標準を被測定点に合わせる。

【0028】ここで、図4に示すように、測地測量装置1の設置位置(測定点)をPとし、被測定点をQとすると、被測定点Qの三軸座標(X, Y, Z)は、次のようにして求める。1.あらかじめ決定され又は高度計で測定した測定点Pの高度Hを、信号処理部60に入力する。2.アウト角度検出器12とインナ角度検出器33から信号処理部60に、アウトジンバル20の回転角度 $\theta 1^\circ$ とインナジンバル30の回転角度 $\theta 2^\circ$ を入力する。3. また、レーザ距離計30から信号処理部60に、測定点Pから被測定点Qまでの距離Lを入力する。4. これら高度H、回転角度 $\theta 1^\circ$ 及び $\theta 2^\circ$ 、距離Lにもとづいて、信号処理部60が、下式(1)～(3)のような演算を

る。

【0029】

$$X = L \cdot \sin \theta 2^\circ \cdot \sin \theta 1^\circ \cdots (1)$$

$$Y = L \cdot \sin \theta 2^\circ \cdot \cos \theta 1^\circ \cdots (2)$$

$$Z = H - L \cdot \cos \theta 2^\circ \cdots (3)$$

【0030】次に、測地測量装置を空中において安定化させる手順について説明する。例えば、図5に示すように、空中浮体2が風等の外乱によって垂直軸Aを中心に時計回りに α°/s で回転すると、空中浮体2に取り付けられたアウトジンバル20も垂直軸Aを中心に時計回りに α°/s で回転する。

【0031】すると、角速度検出器50が、アウトジンバル20の時計回りの角速度 α°/s を検出し、これを信号処理部60に出力する。そして、この信号を入力した信号処理部60が、角速度 α°/s を $-\alpha^\circ/s$ に変換し、これにもとづいてアウトトルクモータ11を駆動させ、アウトジンバル20を反時計回りに α°/s 回動させる。

【0032】これにより、空中浮体2の時計回りの運動と、アウトジンバル20の反時計回りの運動とが互いに打ち消し合い、測地測量装置1を空中において安定化させることができる。すなわち、空中浮体2が回転している状態でも、常に、レーザ距離計30の標準を被測定点に合わせることができる。

【0033】また、空中浮体2が垂直方向に揺動した場合にも、同様の手順でインナジンバル30を、水平軸31を中心に回動させることにより、測地測量装置1を安定化させることができる。

【0034】なお、図示しない地上局から信号処理部60に、角速度検出器50の出力信号と同様の信号を送信することが可能な構成とすれば、前記地上局からの指令によって、インナジンバル30及び／又はアウトジンバル20を強制的に駆動させることができる。

【0035】このような構成によれば、前記地上局からの指令により、レーザ距離計30の標準を自由に変更することができる。

【0036】このような本実施形態の測地測量方法及び測地測量装置によれば、角速度検出器50の出力信号をインナジンバル30及びアウトジンバル20の駆動制御にフィードバックさせるといった簡単な構成によって、風等の外乱により空中浮体2が揺動した場合でも、測地測量装置1を空中において安定化させることができる。

【0037】

【発明の効果】以上のように、本発明の測地測量方法及び測地測量装置によれば、簡単な構成でありながら、風等の外乱により空中浮体が揺動した場合でも、装置を空中において安定化させることができる。

【図面の簡単な説明】

【図1】本発明の一実施形態に係る測地測量装置の運用

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【図2】図1に示す測地測量装置の拡大図である。

【図3】図2に示す測地測量装置のブロック図である。

【図4】本発明の測地測量方法における三次元計測の手順を示す説明図である。

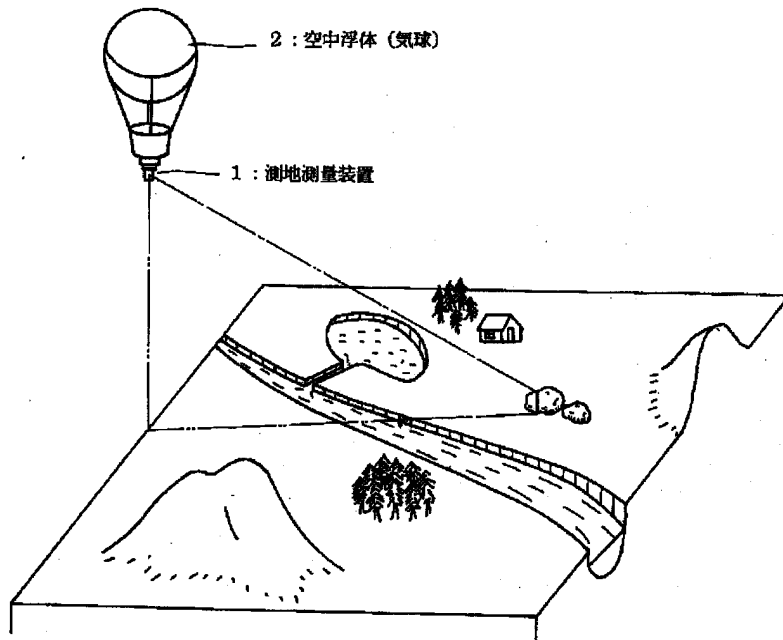
【図5】本発明の測地測量方法における測地測量装置を空中で安定化させる手順を示す説明図である。

【符号の説明】

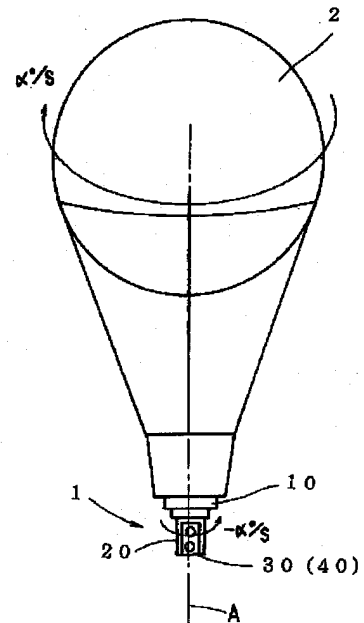
- 1 測地測量装置
- 2 空中浮体（気球）
- 10 ジンバルサポート
- 11 アウトトルクモータ

- 12 アウタ角度検出器
- 20 アウタジンバル
- 21 垂直軸
- 30 インナジンバル
- 31 水平軸
- 32 インナトルクモータ
- 33 インナ角度検出器
- 40 レーザ距離計
- 50 角速度検出器
- 60 信号処理部

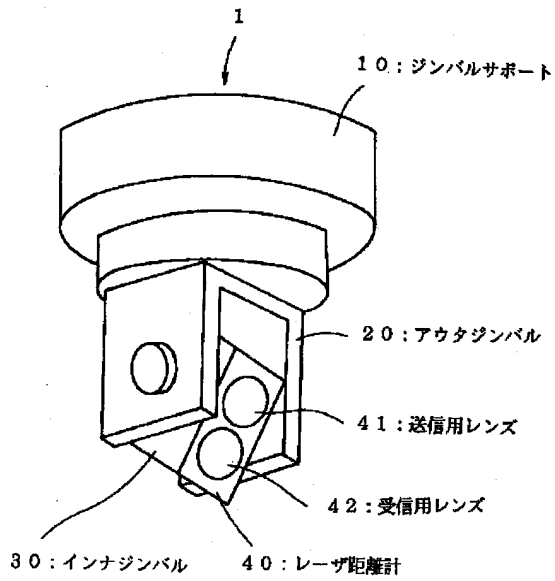
【図1】



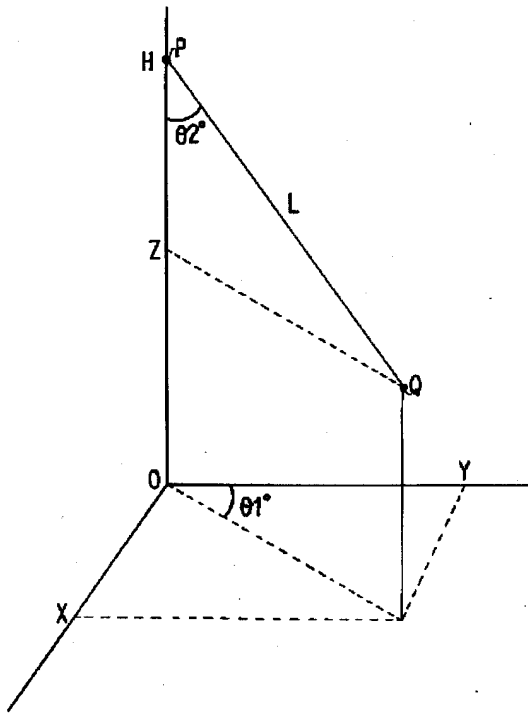
【図5】



【図2】



【図4】



【図3】

